Scalability of IPv6 Transition Technologies for IPv4aaS

draft-lencse-v6ops-transition-scalability

Gábor LENCSE
lencse@sze.hu
Széchenyi István University

Aim and Methodology of the Draft

• Aim
  – To provide IPv6 network operators with information about the scalability of different implementations of various IPv4-as-a-Service (IPv4aaS) technologies

• Methodology
  – Carry out RFC 8219 compliant measurements with free software IPv4aaS implementations
  – Publish all the details in research papers
  – Update the Draft with a summary of the most interesting results and add links pointing to the (open access) paper with the details
Progress of the Draft

• Initial version “00” (Presented at IETF 112)
  – Scalability of **iptables** stateful NAT44 (served only as an example)

• Versions “01”, “02” (Presented at IETF 113)
  – Scalability of the **Jool** Stateful NAT64 implementation
    • Performance characteristics:
      1. maximum connection establishment rate (new, stateful specific metric)
      2. throughput (classic RFC 2544 / RFC 8219 metric)
      3. connection tear down rate (new, stateful specific metric)
    • Measured against
      – the number of CPU cores: 1, 2
      – the number of concurrent sessions: 1, 2, 3
Progress of the Draft

• Version “03” (not presented)
  – Connection tracking table capacity measurements of `iptables`
  – Connection establishment validation of Jool
    • They both were interesting only from measurement methodological point of view

• Version “04” (Presented at IETF 115)
  – Scalability of the `Jool` implementation of 464XLAT and MAP-T
    • Measured with DNS traffic using the `dns64perf++` measurement tool
    • The measurements were not RFC 8219 compliant, but gave an important insight

• Version “05” (current version)
  – Added: scalability measurements of OpenBSD PF
Why OpenBSD PF?

• OpenBSD focuses on security
  
  **Only two remote holes in the default install, in a heck of a long time!**

• PF (Packet Filter) is the firewall of OpenBSD
  
  – Supports stateful NAT64 since OpenBSD 5.1

• The tested version was OpenBSD 7.1
  
  – Having PF as single threaded, thus scalability was not tested against the number of CPU cores
Measurement Environment

• Dell PowerEdge R430 servers
  – Intel Xeon E5-2683v4 CPUs,
  – 384GB 2400MHz DDR4 RAM
  – Intel 10G dual-port X540 NIC
• Direct cable connections
• Tester: Debian 9.13
  – [https://github.com/lencsegabor/siitperf](https://github.com/lencsegabor/siitperf)
• DUT: OpenBSD 7.1

Scalability of IPv4aaS Technologies

IETF 118, v6ops, November 7, 2023. 6
Scalability of OpenBSD PF

- **Maximum Connection Establishment Rate** of OpenBSD PF as a Function of the *Number of Connections*

<table>
<thead>
<tr>
<th>Number of connections</th>
<th>400,000</th>
<th>4,000,000</th>
<th>40,000,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source port numbers</td>
<td>40,000</td>
<td>40,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Destination port numbers</td>
<td>10</td>
<td>100</td>
<td>1,000</td>
</tr>
<tr>
<td>Error (cps)</td>
<td>50</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Median (cps)</td>
<td>120,214</td>
<td>85,039</td>
<td>74,022</td>
</tr>
<tr>
<td>Minimum (cps)</td>
<td>118,701</td>
<td>84,882</td>
<td>73,680</td>
</tr>
<tr>
<td>Maximum (cps)</td>
<td>122,411</td>
<td>85,351</td>
<td>74,266</td>
</tr>
<tr>
<td>Median / previous median</td>
<td>-</td>
<td>0.71</td>
<td>0.87</td>
</tr>
</tbody>
</table>

- The results show an acceptable performance degradation

*This is a new, stateful-specific performance metric*
Scalability of OpenBSD PF

- **Throughput*** of OpenBSD PF as a Function of the *Number of Connections*, Bidirectional Traffic, number of all packets

<table>
<thead>
<tr>
<th>Number of connections</th>
<th>400,000</th>
<th>4,000,000</th>
<th>40,000,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source port numbers</td>
<td>40,000</td>
<td>40,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Destination port numbers</td>
<td>10</td>
<td>100</td>
<td>1,000</td>
</tr>
<tr>
<td>Error (fps)</td>
<td>200</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Median (fps)</td>
<td>237,304</td>
<td>198,828</td>
<td>173,338</td>
</tr>
<tr>
<td>Minimum (fps)</td>
<td>236,912</td>
<td>198,046</td>
<td>172,946</td>
</tr>
<tr>
<td>Maximum (fps)</td>
<td>250,584</td>
<td>199,452</td>
<td>174,120</td>
</tr>
<tr>
<td>Median / previous median</td>
<td>-</td>
<td>0.84</td>
<td>0.87</td>
</tr>
</tbody>
</table>

- The results show an acceptable performance degradation

*This is a classic RFC 2544 / RFC 8219 performance metric*
Scalability of OpenBSD PF

- **Connection Tear Down Rate*** of OpenBSD PF as a Function of the Number of Connections, 16 CPU Cores (*new, stateful-spec.)*

<table>
<thead>
<tr>
<th>Number of connections</th>
<th>400,000</th>
<th>4,000,000</th>
<th>40,000,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source port numbers</td>
<td>40,000</td>
<td>40,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Destination port numbers</td>
<td>10</td>
<td>100</td>
<td>1,000</td>
</tr>
<tr>
<td>Filled table del. time med. (s)</td>
<td>1.45</td>
<td>11.56</td>
<td>94.20</td>
</tr>
<tr>
<td>Filled table del. time min. (s)</td>
<td>1.36</td>
<td>11.03</td>
<td>91.73</td>
</tr>
<tr>
<td>Filled table del. time max. (s)</td>
<td>1.78</td>
<td>13.81</td>
<td>118.52</td>
</tr>
<tr>
<td>Empty table del. time med (s)</td>
<td>0.37</td>
<td>0.37</td>
<td>0.37</td>
</tr>
<tr>
<td>Empty table del. time min (s)</td>
<td>0.36</td>
<td>0.36</td>
<td>0.36</td>
</tr>
<tr>
<td>Empty table del. time max (s)</td>
<td>0.37</td>
<td>0.37</td>
<td>0.37</td>
</tr>
<tr>
<td>Connections deletion time (s)</td>
<td>1.08</td>
<td>11.19</td>
<td>93.83</td>
</tr>
<tr>
<td>Connection tear down r. (cps)</td>
<td>370,370</td>
<td>357,622</td>
<td>426,303</td>
</tr>
</tbody>
</table>
Are you interested in the details?

- All the details and further results can be found in:

- Acknowledgements
  - This work was supported by the International Exchange Program of the National Institute of Information and Communications Technology (NICT), Japan.
  - The experiments were carried out remotely using the resources of NICT StarBED, 2-12 Asahidai, Nomi-City, Ishikawa 923-1211, Japan.
Questions?

- Do you have any questions or concerns to be addressed?
- Do you consider this draft useful?
- Do you think that this draft should be adopted as a WG item?